

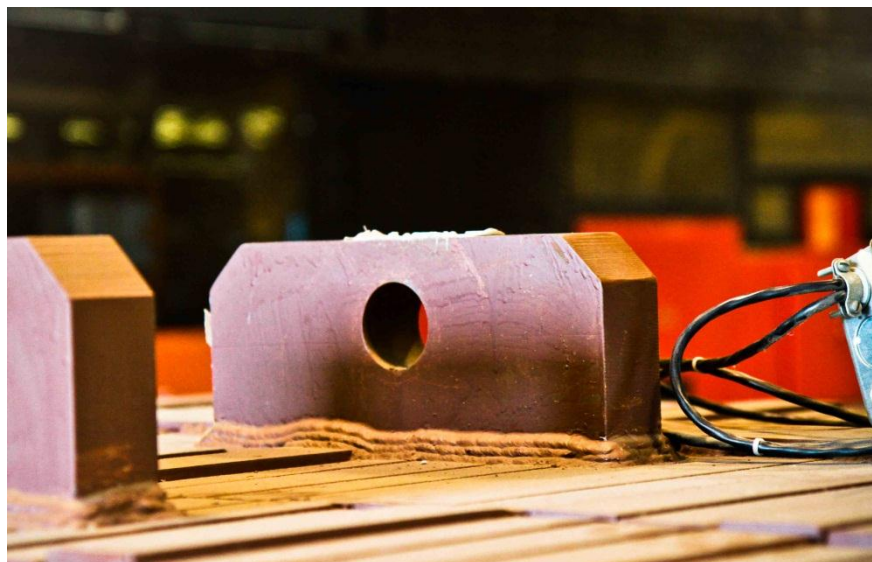


FERMILAB
Technical
Division

Solenoid Lifting Lug Analysis

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Compliance:

Reviewer's Signature:

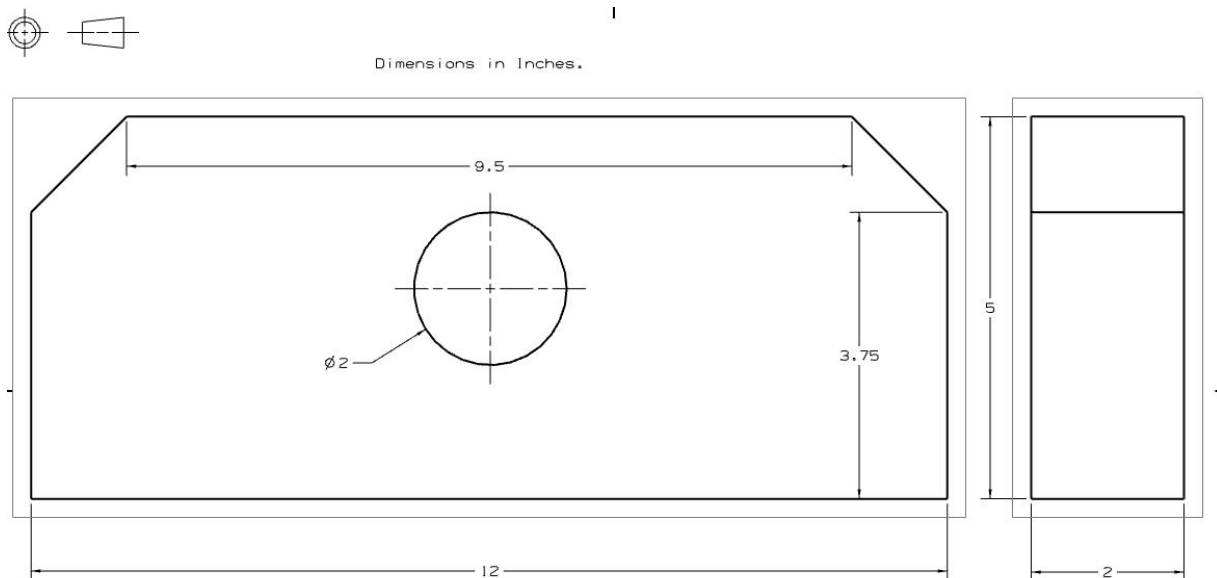
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This document shows analysis which verifies that the magnet can be moved safely by using the lifting lug. Specifically, the analysis will show that the weld between the lifting eye and the solenoid body does not exceed the allowable stress, the stress at the lifting eye does not exceed allowable stress, and the bearing stress is acceptable. The weight of the magnet is 25,000 lbs. The sketch of the lifting lug is shown below:

**Shear Stress at the Weld**

The yield strength of carbon steel at 294K is conservatively 24,000 psi. An allowable stress of 24,000 psi is with a safety factor of 1.0. The *Design of Below-the-Hook Lifting Devices* section in ASME BTH-1-2008 provides the required safety factors. Section 2-2 defines two design categories: Category A, where loads are predictable with minimal overloading; and Category B, where loads and lifting environment are unpredictable. Category B requires the

more conservative safety factor of 3, while Category A requires a safety factor of 2. We will use a safety factor of two because the load is predictable. The allowable stress is then 12,000 psi.

The shear stress on the weld is due to the Force:

$$F = 25000 \text{ lbs}$$

The stress area of the fillet weld of leg t is:

$$A = .707 \times (\text{length}) \times (t) = .707(28 \text{ in}) \times (.43) = 8.51 \text{ in}^2$$

The total shear stress seen by the weld is:

$$\sigma = \frac{F}{A_{\text{attached}}} = \frac{25000}{8.51} = 2938 \text{ psi}$$

The calculated stress of 2938 psi is far less than the allowable stress of 12,000 psi.

Stress at Eye Hook

As mentioned previously, the yield strength of carbon steel at 294K is 24,000 psi. To determine the maximum stress experienced at the lifting eye, an Ansys analysis was conducted. A model of the lifting feature was developed from hand measured dimensions. A 25,000 lb. force was placed on the bottom surface of the part, and the surface of the lifting eye hole was fixed. The analysis shows that the maximum stress experienced by the lifting feature is 5496 psi and the maximum deformation is .0015 in. Using a safety factor of two per ASME BTH-1-2008 results in an allowable maximum stress of 12,000 psi. The maximum stress of 5496 is well within the allowable stress of 12,000 psi. The figures at the end of the document show the stress distribution and total deformation.

Bearing Stress Analysis

The ASME BTH-1-2008 code specifies the maximum allowable bearing stress on the pin/lug interface to be $(1.25 \times F_y) / \text{safety factor}$. With a safety factor of two, the allowable bearing stress is 15,000 psi. Given that the lifting eye is 2 inches in diameter, and assuming the lifting hook to be at least 1.5 inches, the hook/lug interface has an area of $(1.5 \times 2) = 3 \text{ in}^2$. The bearing stress at the interface is then: $25,000 \text{ lb} / 3 \text{ in}^2 = 8333 \text{ psi}$. This is well below the allowable of 15,000 psi.

